



Modelling the interaction between tourism, energy consumption, pollutant emissions and urbanization: renewed evidence from panel VAR

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Received: 20 January 2020 / Accepted: 23 June 2020 / Published online: 7 July 2020

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Abstract

In less than two decades, the global tourism industry has overtaken the construction industry as one of the biggest polluters, accounting for up to 8% of global greenhouse gas emissions as reported by the United Nations World Trade Organization (UNWTO 2018). This position resonates the consensus of the United Nations Framework Convention on Climate Change (UNFCCC). Consequently, research into the causal link between emissions and the tourism industry has increased significantly focusing extensively on top earners from the industry. However, few studies have thoroughly assessed this relationship for small island economies that are highly dependent on tourism. Hence, this study assessed the causal relationship between CO₂ emissions, real GDP per capita (RGDP) and the tourism industry. The analysis is conducted for seven tourism-dependent countries for the period 1995 to 2014 using panel VAR approach, with support from fully modified ordinary least square and pooled mean group–autoregressive distributed lag models. Unit root tests confirm that all variables are stationary at first difference. Our VAR Granger causality/block exogeneity Wald test results show a unidirectional causality flowing from tourism to CO₂ emission, RGDP and energy consumption, but a bi-directional causality exists between tourism and urbanization. This implies that in countries that depend on tourism, the behaviour of CO₂ emission, RGDP and energy consumption can be predicted by the volume of tourist arrivals, but not the other way around. The impulse response analysis also shows that the responses of tourism to shocks in CO₂ appear negative within the 1st year, positive within the 2nd and 3rd years but revert to equilibrium in the fourth year. Finally, the reaction of tourism to shocks in energy consumption is similar to its reaction to shocks in RGDP. Tourism responds positively to shocks in urbanization throughout the periods. These outcomes were resonated by the Dumitrescu and Hurlin causality analysis where the growth-induced tourism hypothesis is validated as well as feedback causality observed between tourism and pollutant emission and urbanization and pollutant emission in the blocks over the sampled period. Consequently, this study draws pertinent energy and tourism policy implications for sustainable tourism on the panel over their growth trajectory without compromise for green environment.

Keywords Energy consumption · GDP · Tourism · Impulse response · Variance decomposition

Responsible Editor: Eyup Dogan

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Introduction

The impact of tourism as a driver of economic and environmental development within small tourism-dependent region has been of importance, especially in terms of its contribution to global carbon emission based on the activities of tourism. In understanding these impacts, the environmental Kuznets curve (EKC) is widely adapted to investigate the interactive influences and casual relationship of components that promotes emission (Shahbaz et al. 2013; Tariq et al. 2017). Hence, EKC model explains the complementary relatedness of socio-eco-environmental variables as they influence carbon emissions, as empirical investigations on the theme has attracted contrary views due to differences in

econometric estimation and representation of important variables (Adebola Solarin et al. 2017;

The role of tourism on emissions is an addition to a number of other interrelated macroeconomic variables (Adedoyin et al. 2020a, b; Adedoyin et al. 2020a, c, b; Adedoyin and Zakari 2020; Etokakpan et al. 2020; Kirikkaleli et al. 2020; Udi et al. 2020). For instance, tourism is recognized as a driver of economic expansion (Ouyang and Lin 2017; Wang et al. 2016; Hossain 2011; Zhang et al. 2018; Yu et al. 2012) which in turn is responsible for the increasing CO₂ emission globally (Dogan and Seker 2016; Dogan and Turkekul 2016; Wang et al. 2016; Dogan et al. 2020; Ertugrul et al. 2016; Inglesi-Lotz and Dogan 2018; Moutinho et al. 2018; Wang et al. 2017; Zameer and Wang 2018; Wen and Shao 2019; Yasmeen et al. 2020) and this threatens the environmental sustenance since this emission leads to extensive global warming. On the other hand, tourism has been attributed to strong economic growth (Diamond 2005), which has led to massive urbanization and industrialization. There is no doubt that industrialization is expected to continue to rise, and this possibility is composite in itself because more industrialization implies more global carbon emission (Schubert et al. 2011; Ouyang and Lin 2017; Wang et al. 2018; Lin and Benjamin 2019; Wang and Su 2019; Yang et al. 2017; Bekhet and Othman 2017; Liu et al. 2018; Pan et al. 2019; Nie et al. 2019; Haug and Ucal 2019; Zameer et al. 2020; Shahbaz et al. 2020).

Furthermore, tourism can be influenced by urbanization and environmental quality (particularly climate) given its over-dependence on climatic resources, which are influenced by geographical conditions and population density especially in small state tourism destinations. Similarly, the influence of economic determinants on carbon emission from tourism is as a result of consumers choice/destination preference and behaviour (household consumption, air and land transportation, accommodation, consumption of goods and services among others) and this has been perceived influence on the

destination (environmental change, energy usage, GDP, income and expenditure, foreign exchange) as adduced by researchers (Dogru et al. 2016; Divisekera 2010).

Another important factor in the tourism–growth–emissions nexus is energy consumption. The “tourism industry” has some influence on economic growth in various regions dependent on tourism, i.e. the attraction of more tourists into destinations will foster economic growth (Dogru and Bulut 2018; Zhang and Zhang 2018; Nie et al. 2019; Akalpler and Hove 2019), and this growth will promote more energy consumption, thereby increasing carbon emissions. Hence, it is established that tourism-induced energy consumption leads to high emissions which consequently have an adverse impact on the quality of the environment in the tourism-dependent countries.

The focus of this study is on tourism-dependent economies. This is because in less than two decades, the global tourism industry has overtaken the construction industry as one of the bigger polluters, accounting for up to 8% of global greenhouse (GHG, hereafter) gas emissions (UNWTO 2018). As shown in Figs. 1 and 2, while international tourist arrivals and urbanization (percentage of urban population) have been on the rise, which necessitates a rise in both energy consumption and real GDP per capita as well between 1995 and 2014, CO₂ emissions have also been on the rise over this period, although with a notable downward trend in 2011 just after the global financial crisis. The theoretical support for the tourism-induced pollutant emission hypothesis is anchored on the environmental Kuznets curve (EKC) setting. It has been a consensus since the seminal study of Kraft and Kraft (1978) on the nexus between energy utilization and GNP for the case of the USA. More recently, tourism demand via international tourist/tourist receipt is considered a driver of pollutant emission. This proposition is hinged on the EKC

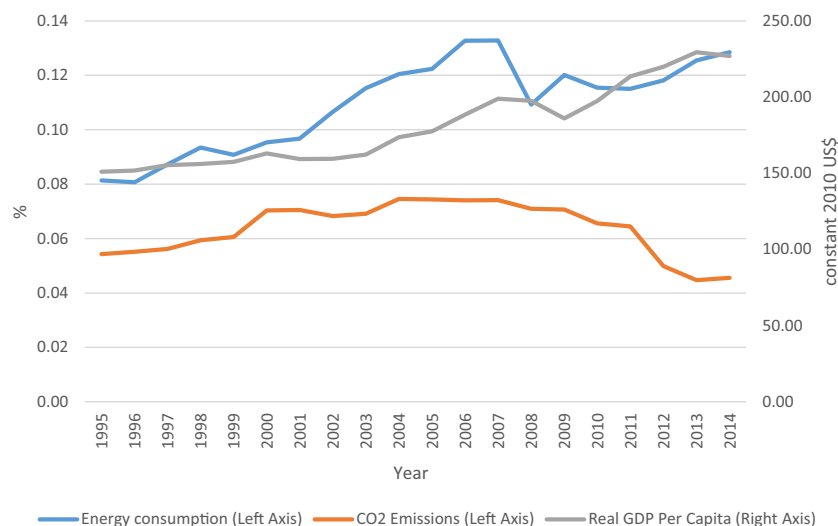
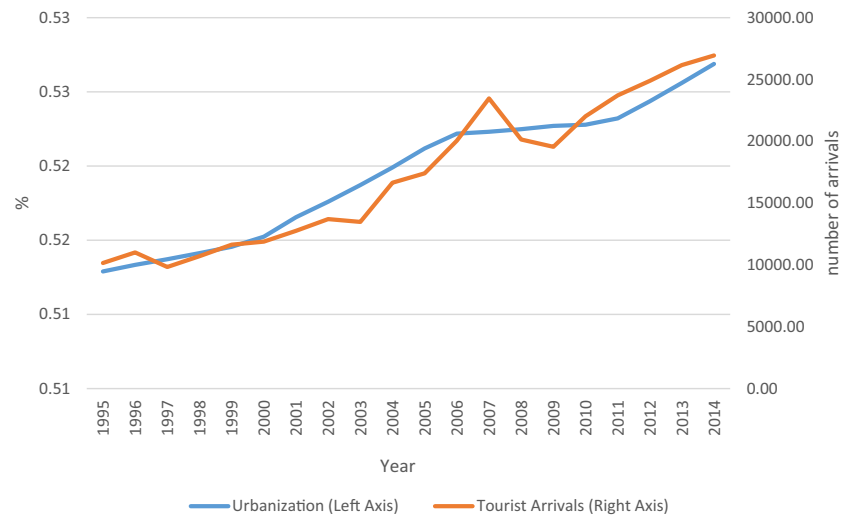


Fig. 1 Energy consumption, CO₂ emissions and real GDP per capita in selected tourism-dependent economies

Fig. 2 International tourist arrivals and share of urban population in selected tourism-dependent economies



phenomenon, where international tourism demand increases energy demand and further translates into an increase in environmental quality (Stern 2004; Katircioglu 2014a, b).

Consequently, research into the causal link between emissions and the tourism industry has increased significantly focusing extensively on top earners from the industry. Thus, it is expected that energy usage could show a positive effect on tourism demand, thereby suggesting a direct relationship between tourism and economic growth. This assertion calls for further concerns on the potential impact of tourism on economic growth and by extension energy demands which has its environmental implications, thereby driving insights into the significance of the connection between these variables (Katircioglu 2014a, b). This proposition is also validated in the study of Roudi et al. (2019) that tourism induces pollutant emission in small island states. In the last two decades, precisely in 2008, the ratification of the United Nations Environment Program (UNEP) in conjunction with the World Tourism Organization (UNWTO) via the Davos Declaration stated approximately 5% of the contribution of tourism-related activities to global GHG emissions.

Therefore, the entire tourism industry has drawn concern as the main contributor to global emissions. The present study focuses on the tourism island-dependent states which are made up of Antigua and Barbuda, Aruba, Bahamas, Macao, Maldives, Seychelles and Vanuatu that constitute mainstay in the region in terms of livelihood provision/earnings and other inherent attributes attached to the tourism sector in the region. However, few studies have thoroughly assessed this relationship for small island economies dependent on tourism. Hence, this paper aims to investigate the causal relationship between CO₂ emissions, real GDP per capita and the tourism industry while accounting for the role of urbanization in a panel setting comprehensively. The current study also distinct from previous in terms of findings from this study is noteworthy as

policymakers in tourism-dependent economies can adopt relevant strategies that not only try to grow the economy through increased volume of international tourist arrivals but also lessen CO₂ emission.

The rest of this study is divided as follows: “Literature review” section presents a review of literature on the nexus between CO₂ emissions, GDP, energy consumption, tourism and urbanization; “Data and methodology” section presents the data and methodology; “Results and discussions” and “Conclusion and policy implications” sections discuss the results and conclusion of the study respectively with vital policy recommendations.

Literature review

Several studies have examined the causal relationship that exists among variables such as carbon emission, GDP, energy consumption, tourism and urbanization (Xu and Zhang 2016; Ma 2015; Yang et al. 2017; Ji and Chen 2017; Ouyang and Lin 2017; Akadiri, 2018; Zhou et al. 2018; Fan and Zhou 2019; Kamran et al. 2019; Etokakpan et al. 2019; Balsalobre-Lorente et al. 2020; Katircioglu et al. 2020; Adedoyin et al. 2020; Udi et al. 2020). For the case of small Island countries, Akadiri et al. (2018) investigated the role of tourism, globalization and economic growth on CO₂ emissions for a group of 16 small island countries over the covering 1995 to 2014. The study which employed a bootstrap granger causality technique validated the presence of demand-flowing and supply-leading hypotheses in the selected countries. Also, the study revealed that there was a feedback effect between tourism and emissions, globalization and emissions and economic growth and emissions in the island countries. Similarly, Katircioglu et al. (2020) examined the tourism–emissions nexus for Northern Cyprus using yearly data covering the period 1977 to 2015. The study which

utilized the autoregressive distributed lag (ARDL) econometric technique found that a rise in tourist activities induces a positive and significant but inelastic impact on emissions ($\beta = 0.351$, $p < 0.05$) in the country. Also, energy consumption and economic growth lead to a positive and significant impact on emissions.

Another study by Seetanah et al. (2019) considered the impact of economic and financial development (FD) on environmental degradation (ED) in 12 small island economies for the period 2000–2016. Utilizing a panel vector autoregressive model, the study confirmed the existence of the environmental Kuznets curve in the selected countries. Also, the study revealed that that GDP per capita has a negative and significant influence on CO₂ emissions while financial development has an indirect impact on emissions in the small island countries. A study by Conrad and Cassar (2014) sought to decouple GDP and emissions in Malta—a small island country using a Driving Force–Pressure–State–Impact–Response (DPSIR) framework. The analysis revealed that GDP played an important role in explaining rising emissions in the country. Specifically, a doubling in nominal GDP was accompanied by a 28% rise in emissions. On the other hand, emissions rose faster than the rate of increase in population. Other factors contributing to increased emissions in the country were also identified such as population and energy consumption.

For related studies in other countries, Xu and Zhang (2016) investigated the link between land urbanization and carbon emissions in China. The study established a bidirectional long-run relationship between land urbanization quality and carbon emissions in China. The study suggested the promotion of land quality and conservation of energy in the country. Also, Ma (2015) found a positive effect of urbanization on overall energy consumption across the provinces in China. The study which employed second generation panel models and data covering the period 1986 to 2011 revealed long-run elasticities of 0.14 to 0.37% on energy consumption.

Concurring to the above, Zhou et al. (2018) found a significant and strong correlation in urbanization subsystems and ecosystem services subsystems (ESS). Significantly, there exists a positive relationship between variables (demographic urbanization, landscape urbanization, economic urbanization and social urbanization); this was represented by an inverse U-shaped curve, implying that urbanization and ESS are well synergized. Another study by Fan and Zhou (2019) found that urbanization and real estate activities have a positive and significant impact on emissions in China. The study which adopted panel model approach also revealed that the cumulative CO₂ emission from 1997 to 2015 increased by 94.29% in the 30 provinces in China with real estate investment contributing majorly with over 106.89% resulting in emission growth based on the rate of urbanization in those provinces. Population and urbanization accounted for CO₂ emissions rise by 13.56% and 69.08% respectively. Furthermore, Su et al.

(2019) revealed that a 1% rise in the variables studied (industry, per capita GDP and urbanization) will drive an increase in CO₂ emission industry ratio by 0.776%, 0.318% and 0.297% on average respectively.

Accordingly, Yu et al. (2012) showed that secondary industries are major emitters of carbon as they compared China's four most urbanized cities with their European counterparts. They concluded that regional disparity policy should be considered to reduce urban emission in China. Sadorsky (2014) investigated the impact of urbanization on CO₂ emission in emerging economies. The study results showed that there exists positive and long-run relationship between the two variables.

Furthermore, Wen and Shao (2019) investigated China's CO₂ emission and other influencing factors using a nonparametric additive regression approach. Their study revealed a nonlinear influence from growth to CO₂ emission. In the study, other factor variables such as energy consumption level (household consumption) exerted an inverted U-type pattern; likewise, industrialization exerted an inverted overturned U-type pattern, and other primary factors such as energy intensity, urbanization and aggregated sales of consumable goods exerted U-type pattern (Wen and Shao 2019).

Urbanization has been seen to deteriorate the quality of the environment; according to He et al. (2016) who revealed that in China, the emergence of “wasted cities and towns” has paralleled urban expansion. They pointed out that unchecked urbanization can lead to wasted cities and towns as a result of the unparalleled effect of rural-urban migration which leads to urban expansion, thereby inflicting a significant rise in social and economic cost hence contributing to poor air quality (Adebola Solarin et al. 2017). To complement the above assertion, Liu et al. (2011) established that an increase in population in a region will invariably increase the rate of pollutants and carbon emissions. Contrary to the above findings, Ra et al. (2016) found that urbanization has no significant impact on carbon emission.

With regard to Africa, Brandful et al. (2015) submit that the trend in Africa's urbanization is a product of a premature pull and push factors which have negatively impacted the rural areas where there is a lag in infrastructure and basic service amenities. Urbanization in Africa is not only limited to increasing the global emission but can also lead to environmental wastage of land resources and energy. Shahbaz et al. (2013), studying the effects of financial development, economic growth, coal consumption and trade on CO₂ emissions in South Africa over the period 1965 to 2008, established a long-run relationship among the variables. The result also confirms that energy emission would increase due to a rise in economic growth, while financial development will reduce it. In other to improve the quality of the environmental status quo, trade was seen as a possibility to reduce the growth of energy pollutants, thereby agreeing with the existence of an environmental Kuznets curve. Empirically, a rise in financial development will significantly lower energy pollutants

improving environmental quality; coal consumption has a negative contribution in that it deteriorates the environmental quality since trade makes the environment better.

Data and methodology

Data

This study uses annual data covering 1995 to 2014 for Antigua and Barbuda, Aruba Bahamas, Macao, Maldives, Seychelles and Vanuatu to examine the causal link among tourist arrivals, real GDP per capita, energy consumption, urbanization and CO₂ emissions described in Table 1. Our study differs from Farhani and Ozturk (2015) which focused on assessing causal links between trade openness, urbanization and other variables. This study also differs from Akadiri et al. (2018), by focusing on international arrivals links with CO₂ emissions for highly tourism-dependent economies instead of tourism island territories.

Model and methods

This study utilizes three econometric techniques namely (i) panel vector autoregressive (PVAR) model created by Love and Zicchino (2006), (ii) fully modified ordinary least square (FMOLS) Pedroni (2004, 2001) and (iii) pooled mean group (PMG). The PVAR model enabled us to represent unobserved singular heterogeneity for the whole data by means of introducing fixed impacts that improve the soundness and the reliability of the estimation. Moreover, the PVAR approach has vital benefits that make it an increasingly reasonable technique to study changes in macroeconomic variables. PVAR is impartial with respect to a specific hypothesis or economic theory and is progressively founded on the contemporary developments of a series. Additionally, PVAR model does not make a differentiation among endogenous and exogenous factors; rather, all factors are commonly treated as endogenous. Each PVAR variable depends on its historical values as well as on different factors, showing a genuine synchronization between the factors and their treatment. PVAR also gives a model to endogenous and exogenous shocks, which are verifiably the most significant sources of macroeconomic dynamics for small economies dependent on tourism. This is particularly important for tourism interconnectedness with CO₂ emissions, urbanization, real GDP per capita and energy consumption for a panel of related economies. Our PVAR model is given by the following:

$$Y_{it} = \theta_i + A(L)Y_{it} + \beta_i + \delta_t + \epsilon_{it} \quad (1)$$

where i and t subscripts represent country and time respectively; Y_{it} represents the vector of CO₂ emissions, real GDP per

capita, energy consumption, tourist arrivals and urbanization; country-specific fixed effect matrix is represented by θ_i ; $A(L)$ is a matrix of lag operator; β_i and δ_t represent each country's individual and time effects respectively; and ϵ_{it} is the vector of residuals (Fig. 6). We use the log form of the variables to ensure a more stable behaviour. Equation (1) form of the PVAR model is further expressed to capture the variables of interest as given below:

$$\begin{aligned} \Delta L(\text{CO2}_{it}) = & \theta_{1i} + \sum_{j=1}^{\rho} a_{1j} \Delta L(\text{CO2}_{it-j}) \\ & + \sum_{j=1}^{\rho} b_{1j} \Delta L(\text{RGDP}_{it-j}) \\ & + \sum_{j=1}^{\rho} c_{1j} \Delta L(\text{ENC}_{it-j}) \\ & + \sum_{j=1}^{\rho} d_{1j} \Delta L(\text{TOU}_{it-j}) \\ & + \sum_{j=1}^{\rho} e_{1j} \Delta L(\text{URB}_{it-j}) + \beta_{1i} + \delta_{1t} \\ & + \epsilon_{1it} \end{aligned} \quad (2)$$

$$\begin{aligned} \Delta L(\text{RGDP}_{it}) = & \theta_{2i} + \sum_{j=1}^{\rho} a_{2j} \Delta L(\text{CO2}_{it-j}) \\ & + \sum_{j=1}^{\rho} b_{2j} \Delta L(\text{RGDP}_{it-j}) \\ & + \sum_{j=1}^{\rho} c_{2j} \Delta L(\text{ENC}_{it-j}) \\ & + \sum_{j=1}^{\rho} d_{2j} \Delta L(\text{TOU}_{it-j}) \\ & + \sum_{j=1}^{\rho} e_{2j} \Delta L(\text{URB}_{it-j}) + \beta_{2i} + \delta_{2t} \\ & + \epsilon_{2it} \end{aligned} \quad (3)$$

$$\begin{aligned} \Delta L(\text{ENC}_{it}) = & \theta_{3i} + \sum_{j=1}^{\rho} a_{3j} \Delta L(\text{CO2}_{it-j}) \\ & + \sum_{j=1}^{\rho} b_{3j} \Delta L(\text{RGDP}_{it-j}) \\ & + \sum_{j=1}^{\rho} c_{3j} \Delta L(\text{ENC}_{it-j}) \\ & + \sum_{j=1}^{\rho} d_{3j} \Delta L(\text{TOU}_{it-j}) \\ & + \sum_{j=1}^{\rho} e_{3j} \Delta L(\text{URB}_{it-j}) + \beta_{3i} + \delta_{3t} \\ & + \epsilon_{3it} \end{aligned} \quad (4)$$

$$\begin{aligned}
\Delta L(\text{TOU}_{it}) = & \theta_{4i} + \sum_{j=1}^{\rho} a_{4j} \Delta L(\text{CO2}_{it-j}) \\
& + \sum_{j=1}^{\rho} b_{4j} \Delta L(\text{RGDP}_{it-j}) \\
& + \sum_{j=1}^{\rho} c_{4j} \Delta L(\text{ENC}_{it-j}) \\
& + \sum_{j=1}^{\rho} d_{4j} \Delta L(\text{TOU}_{it-j}) \\
& + \sum_{j=1}^{\rho} e_{4j} \Delta L(\text{URB}_{it-j}) + \beta_{4i} + \delta_{4t} \\
& + \epsilon_{4it}
\end{aligned} \quad (5)$$

$$\begin{aligned}
\Delta L(\text{URB}_{it}) = & \theta_{5i} + \sum_{j=1}^{\rho} a_{5j} \Delta L(\text{CO2}_{it-j}) \\
& + \sum_{j=1}^{\rho} b_{5j} \Delta L(\text{RGDP}_{it-j}) \\
& + \sum_{j=1}^{\rho} c_{5j} \Delta L(\text{ENC}_{it-j}) \\
& + \sum_{j=1}^{\rho} d_{5j} \Delta L(\text{TOU}_{it-j}) \\
& + \sum_{j=1}^{\rho} e_{5j} \Delta L(\text{URB}_{it-j}) + \beta_{5i} + \delta_{5t} \\
& + \epsilon_{5it}
\end{aligned} \quad (6)$$

In the estimation, we adopt Schwarz's criterion to decide the ideal autoregressive lag length, j . To surmount the imperatives on the parameters in view of their infringement practically speaking, fixed effects are consolidated in Eqs. (1) to (6), to consider singular heterogeneity. The PVAR model permits the consideration of these fixed effects, so as to capture all steady unobserved time factors at country level. The challenge posed by including such time effects is overcome using the forward mean-differencing or unequivocally 'Helmert methodology' (Charfeddine and Kahia 2019; Love and Zicchino 2006; Tiwari 2011). Another bit of flexibility of the PVAR model is taking into account basic time impacts, δ_t , that are relevant in capturing any worldwide macro-economic shocks that potentially will affect all tourism-dependent countries included in our sample correspondingly. To manage time impacts, we differentiate all variables before consideration in the model, and these variables compare to setting dummy in the framework. Besides, assessing the impact of shocks and depicting the effect of the shock of one variable to another variable, while keeping every other variable invariant, is the chief benefit of the PVAR model. This is accomplished with the utilization of impulse response analysis, which depict the response of one variable in light of changes in another variable in the framework since every other shock are kept equivalent to zero. We also present a

variance decomposition analysis, which shows the rate change in a variable disclosed by the shock to another variable aggregated after some time and the extent of the all-out impact.

Before estimating the PVAR model and analysis results of the impulse response function and variance decomposition, we examine stationarity properties of the data by testing the Levin, Lin and Chu t^* and Breitung t stat which both test the null hypothesis of the presence of unit root that assumes common unit root process, as well as Im, Pesaran and Shin W stat; ADF—Fisher chi-square; and the PP—Fisher chi-square tests which all test the null hypothesis that unit root is present and assumes individual unit root process.

Similarly, we use the FMOLS and PMG—ARDL estimators to analyse the tourism—growth—urbanization—energy—emissions nexus. Our estimations are guided by the following equations:

Model 1:

$$\text{LC02} = f(\text{LTOU}, \text{LENC}, \text{LRGDP}, \text{LURB}) \quad (7)$$

$$\begin{aligned}
\text{LC02} = & \alpha_0 + \beta_1 \text{LTOU} + \beta_2 \text{LENC}_{it} + \beta_3 \text{LRGDP} \\
& + \beta_4 \text{LURB}_{it} + \varepsilon_{it}
\end{aligned} \quad (8)$$

Model 2:

$$\text{LRGDP} = f(\text{LTOU}, \text{LENC}, \text{LC02}, \text{LURB}) \quad (9)$$

$$\begin{aligned}
\text{LRGDP} = & \alpha_0 + \beta_1 \text{LTOU} + \beta_2 \text{LENC}_{it} + \beta_3 \text{LC02} \\
& + \beta_4 \text{LURB}_{it} + \varepsilon_{it}
\end{aligned} \quad (10)$$

Model 3:

$$\text{LENC} = f(\text{LTOU}, \text{LRGDP}, \text{LC02}, \text{LURB}) \quad (11)$$

$$\begin{aligned}
\text{LENC} = & \alpha_0 + \beta_1 \text{LTOU} + \beta_2 \text{LRGDP}_{it} + \beta_3 \text{LC02} \\
& + \beta_4 \text{LURB}_{it} + \varepsilon_{it}
\end{aligned} \quad (12)$$

Model 4:

$$\text{LTOU} = f(\text{LENC}, \text{LRGDP}, \text{LC02}, \text{LURB}) \quad (13)$$

$$\begin{aligned}
\text{LTOU} = & \alpha_0 + \beta_1 \text{LENC} + \beta_2 \text{LRGDP}_{it} + \beta_3 \text{LC02} \\
& + \beta_4 \text{LURB}_{it} + \varepsilon_{it}
\end{aligned} \quad (14)$$

Model 5:

$$\text{LURB} = f(\text{LRGDP}, \text{LC02}, \text{LENC}, \text{LTOU}) \quad (15)$$

$$\begin{aligned}
\text{LURB} = & \alpha_0 + \beta_1 \text{LENC} + \beta_2 \text{LRGDP}_{it} + \beta_3 \text{LC02} \\
& + \beta_4 \text{LTOU} + \varepsilon_{it}
\end{aligned} \quad (16)$$

Following Pedroni (1999, 2004, 2001), the long-run relationship is estimated from the FMOLS equation given as follows:

Table 1 Description of variables

| Variable | Code | Unit | Source |
|--|------|--------------------------|--|
| Real GDP per capita | RGDP | Constant 2010 USD | WDI |
| Carbon dioxide (CO ₂) emissions per capita | CO2 | Metric tons | WDI |
| Tourist arrivals | TOU | Number of arrivals | WDI |
| Energy consumption | ENC | Thousand barrels per day | The U.S. Energy Information Administration |
| Urbanization (urban population) | URB | % of total population | WDI |

WDI—World Development Indicators from the World Bank Database. Energy consumption is a sum of oil, gasoline, jet fuel consumption and liquefied petroleum gas consumption all measured in thousand barrels per day

$$Y = \mu_i + x_{i,t}\psi + v_{it} \quad (17)$$

$$x_{i,t} = x_{i,t} + \mathbf{C}_{i,t}$$

where Y is the explained variable, x 5×1 vector of explanatory variables is, μ_i is the intercept while $\mathbf{C}_{i,t}$ and v_{it} are the error terms. However, the estimation of ψ is expressed as follows:

$$\hat{\psi}_{\text{FMOLS}} = \left(\sum_{i=1}^N \sum_{t=1}^T (x_{i,t} - \bar{x}_{i,t}) \times (x_{i,t} - \bar{x}_{i,t})' \right)^{-1} \\ \times \left(\sum_{i=1}^N \left(\sum_{t=1}^T (x_{i,t} - \bar{x}_{i,t}) \times \hat{Y}_{it} - T \hat{\Delta}_{v\mathbf{C}} \right) \right)$$

Also, we analyse both the short- and long-run estimates using the Pesaran et al. (1999) procedure to investigate the tourism–growth–energy–urbanization–emissions nexus presented in Eqs. (7) to (16) in an autoregressive distributed lag (ARDL: p, q) framework that includes lags of both regressands and regressors, given by the following:

$$Y_{it} = \beta_i + \sum_{j=0}^p \delta_{ij} Y_{it-j} + \sum_{j=1}^q \varphi_{i,j} Z_{it-j} + \varepsilon_{it} \quad (18)$$

where Z_{it} is a vector of explanatory variables used in this study. β_i represents the country-level fixed effects, δ_{ij} denotes slope of the lagged emissions variable and $\varphi_{i,j}$ represents slope of lagged explanatory variables.

The ARDL cointegration technique is capable of attending to endogeneity issues in econometric models and at the same time deal with both short-run and long-run parameters. The ARDL cointegration test also can accommodate variables in mixed order of integration such as $I(0)$ or/and $I(1)$. Pesaran et al. (1999) submit that the pool mean group (PMG) estimator is reliable, robust and strong to lag orders and outliers.

Results and discussions

Pre-estimation diagnostics

Table 2 reports the summary of statistics for all the variables. This incorporates the mean, median, maximum and minimum values, standard deviation, skewness, Kurtosis as well as the Jarque–Bera (JB) test measurement which is determined under the null hypothesis that a normal distribution exists for our series. Hence, in light of results of the JB measurement, the

Table 2 Summary statistics

| | CO2 | RGDP | ENC | TOU | URB |
|--------------|----------|-----------|-----------|------------|-----------|
| Mean | 6.365071 | 18,125.69 | 10.94029 | 1,731,311 | 51.95219 |
| Median | 4.45 | 12,890.52 | 7.8 | 583,000 | 45.0575 |
| Maximum | 27.9 | 71,992.03 | 38.78 | 14,566,000 | 100 |
| Minimum | 0.22 | 2481.98 | 0.4 | 44,000 | 20.164 |
| Std. dev. | 7.1974 | 14,035 | 9.27488 | 3,235,408 | 26.93087 |
| Skewness | 1.965925 | 1.345307 | 1.23638 | 2.665128 | 0.681565 |
| Kurtosis | 5.695414 | 5.493476 | 3.6999 | 9.191413 | 2.029595 |
| Jarque–Bera | 132.5608 | 78.49817 | 38.52567 | 389.3471 | 16.33221 |
| Probability | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000284 |
| Sum | 891.11 | 2,537,596 | 1531.64 | 2.42E+08 | 7273.306 |
| Sum sq. dev. | 7200.557 | 2.74E+10 | 11,957.25 | 1.46E+15 | 100,812.8 |
| Observations | 140 | 140 | 140 | 140 | 140 |

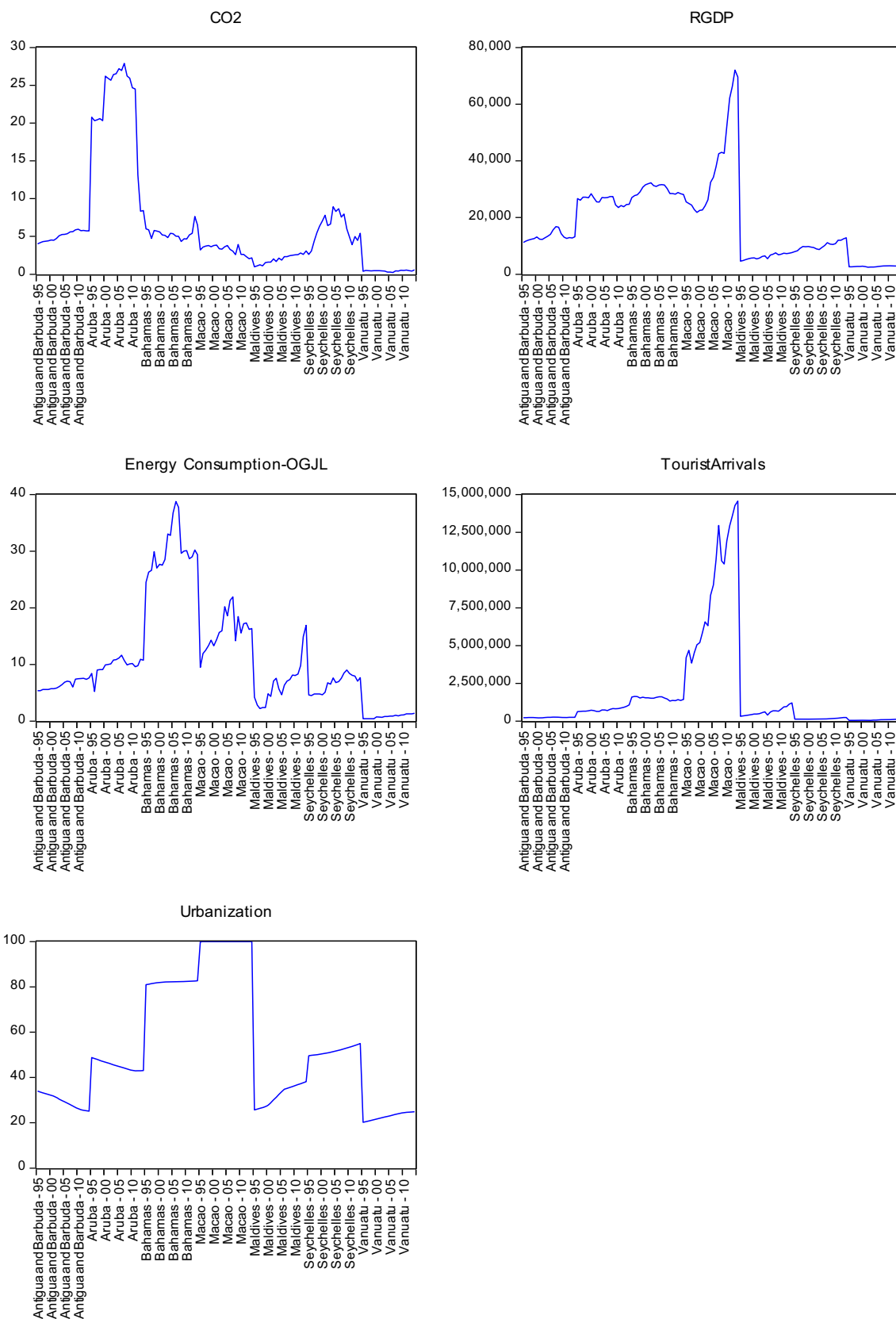


Fig. 3 Trends

null hypothesis cannot be rejected, which suggests that our series are normally distributed.

RGDP is measured in constant 2010 US\$; trend observation for small island economies that seem to be in RGDP is similar to tourist arrivals. The trend for both variables is positive as one variable increases the other variable increases as well. This can be proven as trade openness and urbanization (TOU) has a maximum 14.6 million tourists while RGDP has about US\$72,000 while TOU has a minimum 0.04 million tourists while RGDP has about US\$2500. Trend also reveals that the early years had the minimum values while latter dates have the maximum values. Tourist arrivals measure as TOU are people who visit these small island economics for either a short or long period for reasons ranging from sightseeing, business trips, academic purpose and spiritual rites. Tourism activities have been advancing over the years; this can be justified as tourists get more access to information through advancement in technology and more accessible medium of communication economic rewards, and statistical changes occur between RGDP and TOU.

Furthermore, as shown in Fig. 3, CO₂ emission is seen to be increasing overtime among the small island economies with Vanuatu being with the least growth and Aruba being the highest and constantly increasing CO₂ emitter. CO₂ is measured in metric tons and has an undulating cycle; the least CO₂ emitter is the least consumer of energy, but this is not same for highest energy consumer. Energy consumption is measured in thousand barrels per day with an increase in barrel consumption at the early years of the new millennium for all states of the small island economies. This growth in energy consumption can be due to the fourth industrial revolution that commenced at about the beginning of the new millennium. Urbanization has been growing positively for all states. As shown in Table 3, the study adopts various unit root test to ascertain the stationarity properties of the series and found the all the series to be stationary at first difference. Hence, the VAR model is estimated at first difference.

The correlation matrix (see Appendix Table 6) reveals a significant positive association between the study variables.

Also, we carry out the Pesaran cross-sectional dependence test (see Appendix Table 7). As can be seen, the test reveals evidence of lack of rejection of the null hypothesis of no cross-sectional dependence and that the study variables are not correlated to each other. Furthermore, as expected, we carry out the mandatory unit root tests on the study variables using the augmented Dickey–Fuller and Im, Pesaran and Shin unit root tests. All variables are stationary at first difference. At level, only three variables are stationary in the Im, Pesaran and Shin test while one variable is stationary at level for the augmented Dickey–Fuller test. Hence, we accept that all variables are first-difference stationary.

Accordingly, we proceed to test for a cointegrating relationship among the variables using the Pedroni and Kao cointegration tests. Results from the various tests confirm that there is a cointegration relationship between the study variables; LCO2, LTOU, LRGDP, LURB and LENC.

Causality tests

We conduct the traditional VAR Granger causality/block exogeneity Wald tests; however, we further confirm the behaviour of the variables and their sensitivity is checked using the Dumitrescu–Hurlin causality test (Fig. 4; Table 10). As shown in Table 4, a unidirectional causality is found, which flows from tourism to CO₂ emission, RGDP and energy consumption, but a bi-directional causality exists between tourism and urbanization (URB) in both tests. This implicates that tourism is useful in predicting the behaviour of CO₂ emission, RGDP and energy consumption but not the other way around. Changes in tourism activities will significantly influence these three variables in high magnitude, an increase in tourist pollution will lead to an increase in CO₂ emission RGDP and percent of oil equivalent consumed. Also, a bi-directional causality exists between energy consumption and urbanization. Implicitly, both tourism and urbanization influence each other in the model.

The unidirectional relationship between tourism to CO₂ emission, RGDP and energy consumption is due to tourism

Table 3 Unit root test

| Method | CO2 | D (CO2) | ENC | D(ENC) | TOU | D(TOU) | URB | D(URB) | RGDP | D(RGDP) |
|--|---------|----------|--------|-----------|--------|----------|---------|----------|---------|----------|
| Null: unit root (assumes common unit root process) | | | | | | | | | | |
| Levin, Lin and Chu <i>t</i> * | 1.963 | 0.513 | −1.46* | −3.25*** | −0.257 | −4.57*** | −2.96** | 0.805 | −2.23** | −3.69*** |
| Breitung <i>t</i> stat | 1.652 | −2.61*** | 0.454 | −4.45*** | 1.078 | −4.28*** | 6.329 | −3.85*** | −1.169 | −3.35*** |
| Null: unit root (assumes individual unit root process) | | | | | | | | | | |
| Im, Pesaran and Shin <i>W</i> stat | 1.967 | −3.56*** | −0.55 | −3.49*** | 1.159 | −4.27*** | −0.263 | 2.781 | −1.212 | −2.43*** |
| ADF—Fisher chi-square | 6.408 | 37.90*** | 18.98 | 36.34*** | 9.716 | 43.53*** | 16.494 | 3.527 | 18.955 | 27.79** |
| PP—Fisher chi-square | 27.78** | 83.91*** | 24.65 | 112.13*** | 7.45 | 72.04*** | 31.49** | 1.368 | 16.786 | 46.51*** |

Panel unit root test: summary

***, ** and * represents 1%, 5% and 10% levels of significance

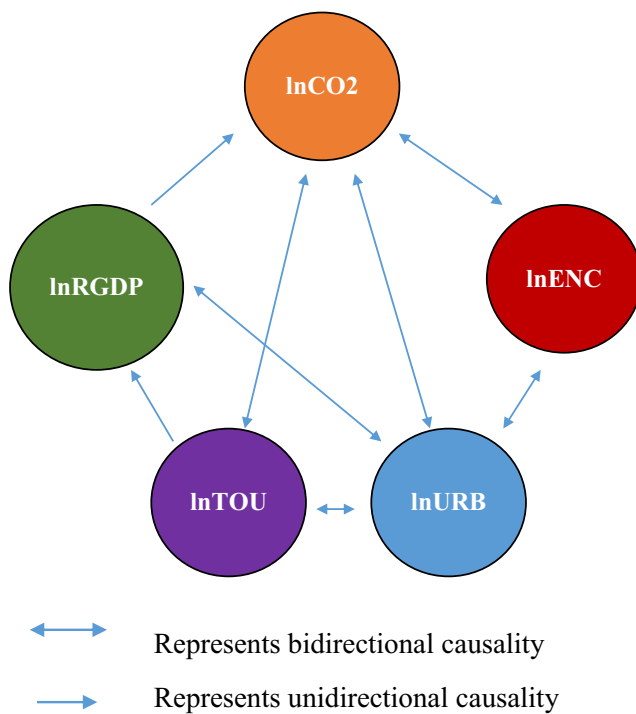


Fig. 4 Results of the Dumitrescu and Hurlin (2012) panel causality

being the major source for economic growth. This implies that small island economies will be free of pollution or pollution, i.e. CO₂ emission will not be significant if tourism activities are not considered. Also, growth in the economy is solely dependent on tourism activities; these states will experience frequent economic cycles based on the numbers of tourists per period. Similarly, energy consumption is heightened by tourism activities.

Policymakers must be able to have a focus and then prepare a strategy to work with it. With the foregoing, a sincere approach to ensure tourism and its externalities are properly managed to bring a fit effect is a responsibility of focus on the aims for environmental policies for small states dependent on tourism as a major income source. Ensuring policies to guide the activities of the tourism sector is a viable approach to succinctly triumph over negative externalities and utilize the positive externalities of the tourism sector in small island economies.

Impulse response

The impulse responses of given variable to shocks in another variable are shown in Fig. 5. It reveals that CO₂ responds positively to a one standard deviation shock in RGDP for the first 3 years but reverts back to equilibrium between the 3rd and the 4th years. For energy consumption, CO₂ responds negatively initially to its positive shock within the first year but soon responds positively to a positive shock within the 2nd and 3rd years and reverts to equilibrium in the 4th year. The responses of CO₂ to a standard deviation shock in tourism

Table 4 Causality test

| VAR Granger causality/block exogeneity Wald tests | | | | |
|---|---------|----|-----------|----------|
| Excluded | Chi-sq | df | Prob. | Decision |
| Null hypothesis: no causality | | | | |
| Dependent variable: CO2 | | | | |
| RGDP | 1.629 | 1 | 0.2018 | Accept |
| ENC | 2.0685 | 1 | 0.1504 | Accept |
| TOU | 2.9028 | 1 | 0.0884* | Reject |
| URB | 1.4712 | 1 | 0.2252 | Accept |
| All | 3.0535 | 4 | 0.5489 | Accept |
| Dependent variable: RGDP | | | | |
| CO2 | 0.2871 | 1 | 0.5921 | Accept |
| ENC | 0.5084 | 1 | 0.4758 | Accept |
| TOU | 15.109 | 1 | 0.0001*** | Reject |
| URB | 0.41712 | 1 | 0.5184 | Accept |
| All | 38.3313 | 4 | 0.0000*** | Reject |
| Dependent variable: ENC | | | | |
| CO2 | 2.2917 | 1 | 0.1301 | Accept |
| RGDP | 2.0862 | 1 | 0.1486 | Accept |
| TOU | 6.1614 | 1 | 0.0131** | Reject |
| URB | 8.0099 | 1 | 0.0047*** | Reject |
| All | 9.421 | 4 | 0.0514** | Reject |
| Dependent variable: TOU | | | | |
| CO2 | 0.0464 | 1 | 0.8294 | Accept |
| RGDP | 0.2613 | 1 | 0.6093 | Accept |
| ENC | 0.7846 | 1 | 0.3757 | Accept |
| URB | 2.7628 | 1 | 0.0965* | Reject |
| All | 3.7114 | 4 | 0.4465 | Accept |
| Dependent variable: URB | | | | |
| CO2 | 0.8008 | 1 | 0.3709 | Accept |
| RGDP | 19.4472 | 1 | 0.0000*** | Reject |
| ENC | 5.3175 | 1 | 0.0211** | Reject |
| TOU | 6.6557 | 1 | 0.0099*** | Reject |
| All | 67.7077 | 4 | 0.0000*** | Reject |

***, ** and * represents 1%, 5% and 10% levels of significance

are similar to that of energy consumption. There is negative response initially with the first year, but entering into the 2nd year, CO₂ responds positively to a positive shock in tourism to the third year, but the effects of tourism on CO₂ become neutralized in the fourth year. CO₂, however, responds only marginally to shocks in urbanization throughout the periods.

The RGDP responds positively to shocks in CO₂ within the first 3 years and reverts back to equilibrium thereafter. It, however, responds similarly to shocks in energy consumption and tourism. There is negative response in the first year but soon responds positively within the 2nd and 3rd years and reverts back to equilibrium in the fourth year. The responses of RGDP to shocks in urbanization are marginally positive throughout the periods.

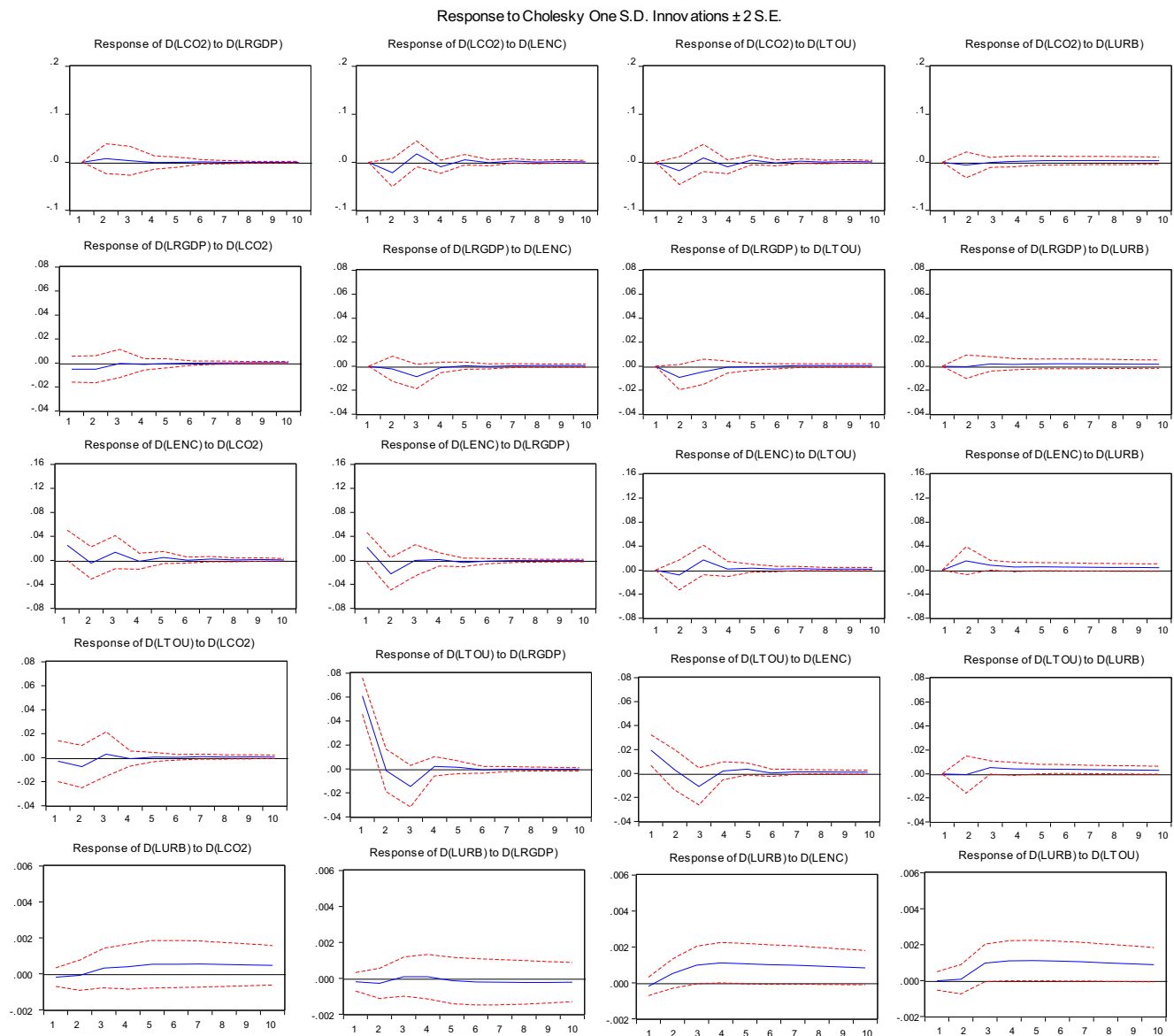


Fig. 5 Impulse response

For energy consumption, it reacts negatively initially within the first year to shocks in CO_2 , but within the 2nd and 3rd years, energy consumption responds positively to a positive shock in CO_2 and reverts back to equilibrium in the fourth year. For RGDP, just like CO_2 , energy consumption responds negatively to shocks in RGDP in the first year, but with the second and the third years, a shock in RGDP generates a positive response from energy consumption and reverts back to equilibrium in the 3rd year. The responses of energy consumption to shocks in tourism are similar to its responses to RGDP, except that it takes 4 years to revert to equilibrium. Energy consumption responds positively to positive shocks in urbanization till the 4th year when it reverts to equilibrium.

The responses of tourism to shocks in CO_2 appear negative within the 1st year, positive within the 2nd and 3rd years and revert to equilibrium in the fourth year. It responds negatively to shocks in RGDP to the 3rd year, picks up in the 4th year and reverts to equilibrium within the 4th and 5th years. The reaction of tourism to shocks in energy consumption is similar to its reaction to shocks in RGDP. Tourism responds positively to shocks in urbanization throughout the periods. Urbanization responds positively to shocks in CO_2 throughout the periods, negatively to shock in RGDP in the first year and adjusted positively within the 2nd and 3rd years. It responds positively to shocks in energy consumption and tourism throughout the periods, except that for tourism, the responses start in the 2nd year.

Table 5 Variance decomposition

| Series | Period | D(LCO ₂) | D(LRGDP) | D(LENC) | D(LTOU) | D(LURB) |
|----------------------|--------|----------------------|----------|---------|---------|---------|
| D(LCO ₂) | 1 | 100 | 0 | 0 | 0 | 0 |
| | 2 | 96.760 | 0.187 | 1.764 | 1.167 | 0.121 |
| | 3 | 95.657 | 0.203 | 2.663 | 1.361 | 0.115 |
| | 4 | 95.033 | 0.204 | 2.956 | 1.681 | 0.126 |
| D(LRGDP) | 1 | 0.787 | 99.213 | 0.000 | 0.000 | 0.000 |
| | 2 | 1.475 | 96.061 | 0.139 | 2.318 | 0.008 |
| | 3 | 1.439 | 93.530 | 2.122 | 2.819 | 0.089 |
| | 4 | 1.470 | 93.411 | 2.151 | 2.822 | 0.146 |
| D(LENC) | 1 | 3.263 | 2.452 | 94.285 | 0.000 | 0.000 |
| | 2 | 3.157 | 4.746 | 90.608 | 0.321 | 1.168 |
| | 3 | 3.922 | 4.617 | 88.367 | 1.648 | 1.446 |
| | 4 | 3.924 | 4.610 | 88.237 | 1.659 | 1.569 |
| D(LTOU) | 1 | 0.101 | 42.571 | 4.401 | 52.927 | 0.000 |
| | 2 | 0.718 | 41.142 | 4.345 | 53.790 | 0.004 |
| | 3 | 0.786 | 41.775 | 5.434 | 51.703 | 0.301 |
| | 4 | 0.790 | 41.670 | 5.463 | 51.600 | 0.477 |
| D(LURB) | 1 | 0.440 | 0.493 | 0.504 | 0.006 | 98.557 |
| | 2 | 0.200 | 0.594 | 1.460 | 0.024 | 97.722 |
| | 3 | 0.404 | 0.363 | 3.572 | 2.677 | 92.984 |
| | 4 | 0.601 | 0.272 | 5.033 | 4.333 | 89.761 |

Cholesky ordering: D(LCO₂) D(LRGDP) D(LENC) D(LTOU) D(LURB)

Variance decomposition analysis

The variance decomposition is shown in Table 5. We find that own shocks account for total variation in CO₂ in the first year, but the effect of own shock diminishes throughout the periods. RGDP and URB account for less than 1% variation in CO₂ through the for years, while energy consumption accounts for 1.76%, 2.66% and 2.96% variation in CO₂ in the 2nd, 3rd and 4th years respectively. Tourism on the other hand accounts for 1.67%, 1.36% and 1.68% variation in CO₂. Tourism accounts for more variation in CO₂ in the model, other than energy consumption. This outcome implies that tourism and energy consumption contribute more significantly to emissions in the study countries.

Tourism accounts for more variation in RGDP than other variables throughout the periods considered, except for the first year. It has no influence on RGDP in the first year; however, it has accounted for about 2.32%, 2.82% and 2.82% variation in RGDP in the 2nd, 3rd and 4th years respectively. This implies that tourism is a major economic activity for the small island countries. CO₂ accounts for less than 2% variation in RGDP throughout the periods. It has 0.79%, 1.48%, 1.44% and 1.47% influence on RGDP in the 1st, 2nd, 3rd and 4th years respectively. Energy consumption (ENC) has no influence on RGDP in the 1st year, but accounts for about 0.13%, 2.12% and 2.15% variation in RGDP in the 2nd, 3rd

and 4th years respectively. URB has marginal effect of less than 1% on RGDP throughout the periods considered.

CO₂ and RGDP account for greater variation in ENC than other variables in the model. CO₂ accounts for about 3.26%, 3.16%, 3.92% and 3.92% variation in energy consumption in the 1st, 2nd, 3rd and 4th years respectively, while RGDP accounts for about 2.45%, 4.75%, 4.62% and 4.61% variation in energy consumption. Both TOU and URB have no influence on ENC in the first year, while TOU accounts for about 0.32%, 1.65% and 1.66% variation in ENC in the 2nd, 3rd and 4th years respectively, URB accounts for 1.17%, 1.45% and 1.56% variation in ENC in the 2nd, 3rd and 4th years respectively.

RGDP accounts for a much significant variation in TOU. It accounts for about 42.57%, 41.14%, 41.78 and 41.67% variation in TOU in the 1st, 2nd, 3rd and 4th years respectively. Both CO₂ and URB account marginally for changes in TOU. They account for less than 1% variation in TOU throughout the 4-year period. ENC accounts for about 4.40%, 4.35%, 5.43% and 5.46% variation in TOU in the 1st, 2nd, 3rd and 4th years respectively. ENC accounts for more variation in URB than any other variables in the model throughout the period. It has 0.50%, 1.46%, 3.57% and 5.03% influence on URB in the 1st, 2nd, 3rd and 4th years respectively. Both CO₂ and RGDP have less than 1% influence on URB for the entire period considered. Likewise, TOU accounts for less than 1%

variation in URB in the first 2 years but explains a 2.68% and 4.33% variation in URB in the 3rd and 4th years.

Fully modified ordinary least square regression

Table 8 (see [Appendix](#)) shows result for FMOLS estimates for the five equations specified earlier in the study. Beginning with model 1, results reveal that economic growth has a positive effect on emissions ($\beta = 0.260$, $p > 0.01$) in the study countries. Similarly, an increase in energy consumption induces high emissions ($\beta = 0.235$, $p > 0.01$). On the other hand, tourism has a negative impact on emissions ($\beta = -0.0534$, $p > 0.05$). Urbanization also has a negative impact on emissions ($\beta = -0.793$, $p > 0.01$) in the focus countries. Additionally, in model 2, we consider the determinants of economic growth in the selected countries. The model is consistent and significant. We find that emissions have a positive impact on economic growth as shown by the positive and significant coefficient of LCO2 ($\beta = 1.545$, $p > 0.01$), while energy consumption in the selected countries has a negative impact on economic growth ($\beta = -0.319$, $p > 0.01$), signifying that a rise in energy consumption leads to a fall in economic growth. On the other hand, a rise in tourism induces economic growth ($\beta = 0.696$, $p > 0.01$) which is evident in support of the importance of tourism as a major economic activity in the seven island countries. Lastly, urbanization is also a driver of economic growth as expected. A rise in urban expansion increases the demand for housing activities and finished goods which increases economic output ($\beta = 1.241$, $p > 0.01$).

Also, in model 3, we find that emissions contribute to rising energy consumption ($\beta = 0.662$, $p > 0.01$) as shown by the results. Emissions emerging from combustible energy induce higher consumption of energy in the island countries. However, a rise in economic growth will lead to a fall in energy consumption ($\beta = -0.152$, $p > 0.01$) as shown by the negative and significant coefficient of LRGDP. Tourism has a negative but insignificant impact on energy consumption, while a rise in urbanization will bring about a reduction in energy consumption ($\beta = -0.489$, $p > 0.01$). Furthermore, in model 4, emissions have no significant impact on tourist arrivals in the study countries. On the other hand, a rise in economic growth will bring about a rise in tourist arrivals ($\beta = 0.361$, $p > 0.01$) in the island countries which entails that a rise in economic activities especially in putting in place tourist transport and accommodation induces a rise in tourist visits to the countries. Energy consumption, however, has no significant impact on tourist arrivals, while a rise in urbanization reduces the number of tourist arrivals ($\beta = -0.420$, $p > 0.01$) in the island countries. In model 5, results reveal that as emissions increase, the rate of urbanization falls ($\beta = -0.690$, $p > 0.01$). Similarly, economic growth drives an increase in urbanization ($\beta = 0.182$, $p > 0.01$). The expansion of industries in the cities leads to a demand for labour which

attracts labour from nonurban areas to urban areas. On the other hand, a rise in energy consumption reduces the rate of urbanization ($\beta = -0.150$, $p > 0.01$) while a rise in tourism also reduces urbanization ($\beta = -0.111$, $p > 0.01$).

Robustness checks: pooled mean group estimates

In Table 9 (see [Appendix](#)), we presented short-run and long-run estimate results for the PMG-ARDL. Beginning with model 1, results reveal that economic growth has no impact on emissions in the short run, while it has a positive impact on emissions in the long run ($\beta = 0.509$, $p > 0.1$) in the study countries. An increase in energy consumption induces high emissions in the short run ($\beta = 0.248$, $p > 0.01$) and in the long run ($\beta = 0.921$, $p > 0.01$). On the other hand, tourism has a negative impact on economic growth ($\beta = -0.549$, $p > 0.05$) in the long run, but there is no significant relationship between the two variables in the short run. Urbanization also has a negative impact on emissions in the short run ($\beta = -48.78$, $p > 0.01$) and in the long run ($\beta = -0.479$, $p > 0.01$) in the focus countries. Additionally, in model 2, a rise in emissions leads to a fall in economic growth in the long run ($\beta = -0.259$, $p > 0.05$) but has no significant impact in the short run, while a rise in energy consumption leads to a fall in economic growth ($\beta = -0.247$, $p > 0.05$) but no impact in the short run. Similarly, an increase in urbanization will also lead to a fall in economic growth ($\beta = -0.876$, $p > 0.01$). On the other hand, tourism induces an increase in economic growth in the short run ($\beta = 0.587$, $p > 0.01$) and the long run ($\beta = 0.445$, $p > 0.01$). However, the error correction term is not significant which implies that there is no long-run relationship in the model.

As shown in model 3, emissions contribute positively to high energy consumption in the short run ($\beta = 0.35$, $p > 0.1$) and in the long run ($\beta = 1.034$, $p > 0.01$). Economic growth and urbanization have no impact on energy consumption in the short run and long run, while a rise in tourism brings about an increase in energy consumption in the long run ($\beta = 0.529$, $p > 0.01$) only. Also, results, shown in model 4, reveal that as CO₂ emissions increase, urbanization falls ($\beta = -0.0363$, $p > 0.01$) in the long run only, while economic growth contributes positively to urbanization in the short run ($\beta = 0.0166$, $p > 0.01$) and in the long run ($\beta = 0.416$, $p > 0.01$). On the other hand, a rise in tourism will be followed by a fall in urbanization in the short run and in the long run ($\beta = -0.479$, $P > 0.01$) and the short run ($\beta = -0.0103$, $p > 0.05$). However, the error correction term is not significant which implies that there is no long-run relationship in the model. Finally, results, from model 5, reveal that CO₂ emissions has no significant impact on tourism arrivals in the study countries, while economic growth has a positive effect on tourism arrivals in the short run ($\beta = 0.953$, $p > 0.01$) and the long run ($\beta = 1.171$, $p > 0.01$). Similarly, energy consumption contributes positively to tourist arrivals in the long run ($\beta = 0.182$,

$p > 0.05$) but no impact in the short run. A rise in urbanization also leads to high tourist activities in the selected countries only in the long run ($\beta = 0.182$, $p > 0.1$).

Comparison with previous findings

The findings of this study are consistent with previous studies as contained in the literature review. Beginning with the determinants of emissions in the island countries, results illustrated that tourist activities and urbanization are leading emitters of CO₂ in the focus countries. This finding is similar to that of Xu and Zhang (2016) and Akadiri et al. (2018) for 16 small developing island economies, Balsalobre-Lorente et al. (2020) for Spain and Katircioglu et al. (2020) for Cyprus. However, this finding is contrary to that of Ra et al. (2016) who found that urbanization has no impact on emissions. Similarly, economic growth and energy consumption also contribute positively to emissions as revealed by Su et al. (2019) for China and Dogru et al. (2016) for the Mediterranean Area but is contrary to Seetanah et al. (2019) who found a negative relationship between economic growth and emissions for Malta.

The findings that tourism and energy are positively related to growth corroborate the findings of Farhani and Ozturk (2015) for Tunisia and Yang et al. (2018) for China. Similarly, the causation from urbanization to growth is similar to the findings in Hossain (2011) for selected newly industrialized.

For urbanization, the positive relationship between economic growth and urbanization corroborates with the findings of Shahbaz et al. (2013) for South Africa. The negative relationship between emissions and urbanization is contrary to the findings of He et al. (2016) who found a positive relationship between the two variables in China, while the negative relationship between tourism and urbanization agrees partially with the findings of Akadiri et al. (2018) for small island countries.

The positive but insignificant impact of emissions on energy consumption is partially similar to the finding of Ma (2015) for China, while the positive influence exerted by economic growth on energy consumption agrees with the results in Dogan et al. (2020) for 17 African countries. For tourism, the positive influence of economic growth on tourism agrees with the findings of Nepal et al. (2019), while the causation from emissions to tourism arrival and from energy consumption to tourist arrival corroborates with the findings of Katircioglu (2014a, b) for Cyprus.

Conclusion and policy implications

Utilizing information explicit to seven tourism-dependent economies for the period 1995 to 2014, this investigation

inspected the causality connections between international tourist arrivals, real GDP per capita, CO₂ emissions, energy consumption and urbanization. Panel VAR econometrics techniques dependent on unit root tests were adopted with Granger causality tests; impulse response analysis as well as variance decomposition analysis were applied to test how activities in the tourism industry interact with energy consumption and CO₂ emissions. Also, dynamic panel data methods such as fully modified ordinary least squares (FMOLS) and pooled mean group (PMG) methods were used to make the findings of the study more robust and reliable. Both short- and long-term dynamics were assessed using these diverse modeling techniques. This is because for tourism-dependent economies, apart from the rural-urban migration and congestion tendencies in tourists' attractions for business purposes, shocks to tourist arrivals and energy consumption hypothetically have a potential adverse impact on CO₂ emissions.

Consequently, our research findings are vital for achieving sustainable tourism and environmental objectives. As expected, unlike in countries that do not depend heavily on tourism (Nepal et al. 2019), international tourist arrivals account for more variation in real GDP per capita in tourism-dependent economies. As with existing studies, energy consumption accounts for variation in CO₂ emissions which is followed by international tourist arrivals. This necessitates more government policies that cater for mitigating deteriorating global climate, since long-term consequences can hamper the growth of the economy. Also, in the long run, increase in energy consumption could prevent tourists from visiting or reducing visits to destinations that rely heavily on them, due to uncontrolled environmental damage. Consequently, green energy sources and energy from other existing renewable sources should be giving more consideration for every tourism service provided or product sold in the tourism industry of these countries. The use of renewable energy will lower the levels of emissions in the small island countries, thus preserving the environment and making it useful for sustainable tourism. Additionally, since tourism-dependent economies are mainly attractive destinations, it is vital to revisit and/or pay attention to the maximum capacity of the travel industry to help in creating a workable balance with urban-rural drift since many of these countries are developing countries.

In order to achieve stable and sustained economic growth in the island countries, it is important that the government of the countries focuses on expanding economic activities into other sectors which can be supported by the natural resources in the islands. Such activities include fishing, construction and services. Revenue accrued from tourist activities can be used to build urban infrastructure which could boost the expansion and establishment of other economic activities. Moreover, the study has shown that a rise in urban centres induces a rise in economic growth.

Appendix

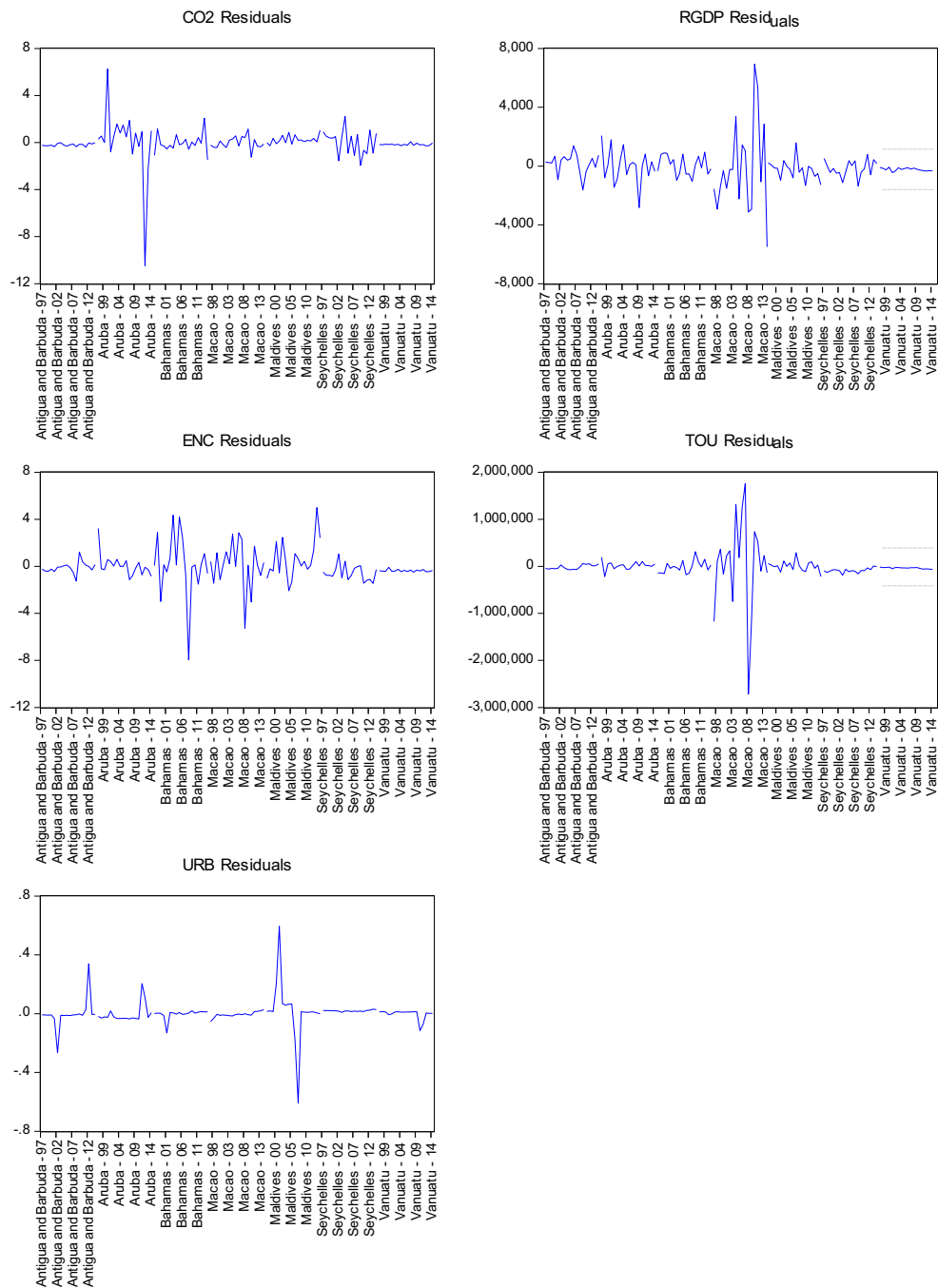


Fig. 6 Residual plot

Table 6 Correlation matrix

| Variables | LNCO2 | LRGDP | LENC | LTOU | LURB |
|-----------|---------|---------|---------|---------|--------|
| LNCO2 | 1.0000 | | | | |
| LRGDP | 0.7267* | 1.0000 | | | |
| LENC | 0.6863* | 0.8829* | 1.0000 | | |
| LTOU | 0.3494* | 0.8183* | 0.7785* | 1.0000 | |
| LURB | 0.4353* | 0.8245* | 0.8152* | 0.8254* | 1.0000 |

* represents 10% levels of significance

Table 7 Pre-estimation diagnostics**Results from cross-sectional dependence test**

| Test | Statistic | Prob. |
|-----------------------------------|---------------|--------------|
| Pearson LM normal | 23.725 | 0.3066 |
| Pearson CD normal | − 0.008 | 0.9934 |
| Pedroni cointegration test | | |
| Panel ν statistic | − 0.5795 | .2811 |
| Panel Rho statistic | 0.7606 | 0.7765 |
| Panel PP statistic | − 1.636 | 0.050* |
| Panel ADF statistic | − 1.645 | 0.0499** |
| Group Rho statistic | 1.262 | 0.8965 |
| Group PP statistic | − 4.949 | 0.0000*** |
| Group ADF statistic | − 3.481 | 0.0002*** |
| Kao cointegration test | | |
| | t stat | Prob. |
| ADF | − 3.9655 | 0.0000*** |

Null hypothesis: cross-sectional independence ($CD \sim (0, 1)$). Dependent variable = CO₂ emissions. ν , Rho, PP and ADF statistics are measured using Pedroni (2004, 1999). p values are given in parentheses

PP Phillips–Perron, ADF augmented Dickey–Fuller

***, ** and * represent a statistical rejection level of the null of no cointegration at 1%, 5% and 10% significance levels respectively

Table 8 FMOLS regression results

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|-----------|------------------------|------------------------|------------------------|----------------------|------------------------|
| lnCO2 | | 1.545*** (0.0524) | 0.662*** (0.0662) | − 0.208 (0.210) | − 0.690*** (0.0391) |
| lnRGDP | 0.260*** (0.0141) | | − 0.152*** (0.0289) | 0.361*** (0.0745) | 0.182*** (0.0211) |
| lnENC | 0.235*** (0.0242) | − 0.319*** (0.0393) | | − 0.0229 (0.125) | − 0.150*** (0.0334) |
| lnTOU | − 0.0534** (0.0244) | 0.696*** (0.0322) | − 0.0387 (0.0399) | | − 0.111*** (0.0316) |
| lnURB | − 0.793*** (0.0318) | 1.241*** (0.0641) | − 0.489*** (0.0746) | − 0.420* (0.222) | |
| Constant | 2.063*** (0.316) | − 5.229*** (0.482) | 4.358*** (0.502) | 10.75*** (0.971) | 4.426*** (0.333) |
| R-squared | 0.968 | 0.618 | 0.911 | 0.522 | 0.957 |

Standard errors in parentheses

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 9 Pooled mean group with dynamic autoregressive distributed lag (PMG–ARDL (1, 1, 1, 1, 1))

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|-----------|------------------------|-----------------------|------------------------|-------------------------|------------------------|
| Long run | | | | | |
| LCO2 | | − 0.259** (0.114) | 1.034*** (0.198) | − 0.0363** (0.0164) | − 0.0466 (0.0769) |
| LRGDP | 0.00392 (0.212) | | 0.0810 (0.214) | 0.416*** (0.2145) | 1.171*** (0.186) |
| LENC | 0.921*** (0.173) | − 0.247** (0.107) | | | 0.182** (0.0741) |
| LURB | − 0.479** (0.229) | − 0.876*** (0.298) | 0.347 (0.299) | | 0.314* (0.179) |
| LTOU | − 0.549** (0.243) | 0.587*** (0.166) | 0.529*** (0.201) | − 0.479*** (0.0824) | |
| Short run | | | | | |
| ECT (− 1) | − 0.284*** (0.0739) | − 0.115 (0.0821) | − 0.303*** (0.0979) | − 0.0130 (0.00994) | − 0.303*** (0.0352) |
| LCO2 | | 0.0263 (0.0579) | 0.359* (0.191) | − 0.0170 (0.0158) | − 0.0609 (0.0593) |
| LRGDP | 0.509* (0.283) | | 0.283 (0.424) | 0.0166*** (0.00511) | 0.953*** (0.198) |
| LENC | 0.248** (0.125) | 0.0186 (0.0226) | | | 0.0490 (0.103) |
| LURB | − 48.78** (24.66) | − 7.812 (15.00) | 31.92 (36.12) | | − 15.17 (10.99) |
| LTOU | − 0.490 (0.311) | 0.445*** (0.0795) | 0.0118 (0.302) | − 0.0103** (0.00490) | |
| Constant | − 2.395*** (0.687) | − 0.798* (0.452) | 2.650*** (0.836) | − 0.211** (0.0172) | − 0.178** (0.0822) |

Standard errors in parentheses

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$ **Table 10** Results of the Dumitrescu and Hurlin (2012) panel causality

| Null hypothesis | W stat. | P value |
|--------------------------------------|------------|---------|
| $\ln\text{CO}_2 \neq \ln\text{RGDP}$ | 5.3175*** | 0.0000 |
| $\ln\text{RGDP} \neq \ln\text{CO}_2$ | 1.6866 | 0.1989 |
| $\ln\text{CO}_2 \neq \ln\text{LENC}$ | 2.1999** | 0.0248 |
| $\ln\text{LENC} \neq \ln\text{CO}_2$ | 3.9867*** | 0.0000 |
| $\ln\text{CO}_2 \neq \ln\text{TOU}$ | 3.1010*** | 0.0001 |
| $\ln\text{TOU} \neq \ln\text{CO}_2$ | 1.8908* | 0.0956 |
| $\ln\text{CO}_2 \neq \ln\text{URB}$ | 2.9511*** | 0.0003 |
| $\ln\text{URB} \neq \ln\text{CO}_2$ | 23.5502*** | 0.0000 |
| $\ln\text{RGDP} \neq \ln\text{LENC}$ | 1.1856 | 0.7284 |
| $\ln\text{LENC} \neq \ln\text{RGDP}$ | 0.7714 | 0.6689 |
| $\ln\text{RGDP} \neq \ln\text{TOU}$ | 3.0899*** | 0.0001 |
| $\ln\text{TOU} \neq \ln\text{RGDP}$ | 0.5705 | 0.4217 |
| $\ln\text{RGDP} \neq \ln\text{URB}$ | 3.8802*** | 0.0000 |
| $\ln\text{URB} \neq \ln\text{RGDP}$ | 4.5182*** | 0.0000 |
| $\ln\text{LENC} \neq \ln\text{TOU}$ | 1.3099 | 0.5620 |
| $\ln\text{TOU} \neq \ln\text{LENC}$ | 1.0560 | 0.9165 |
| $\ln\text{LENC} \neq \ln\text{URB}$ | 4.3711*** | 0.0000 |
| $\ln\text{URB} \neq \ln\text{LENC}$ | 2.8757*** | 0.0004 |
| $\ln\text{TOU} \neq \ln\text{URB}$ | 2.1948** | 0.0254 |
| $\ln\text{URB} \neq \ln\text{TOU}$ | 7.1376*** | 0.0000 |

***, ** and * represent 0.01, 0.05 and 0.10 rejection levels respectively
 \neq , \rightarrow and \leftrightarrow represent no Granger causality, one-way causality and bi-directional causality respectively

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